

Synopsis of the Tortugas Pink Shrimp Fishery, 1960-1983, and the Impact of the Tortugas Sanctuary

EDWARD F. KLIMA, GEOFFREY A. MATTHEWS, AND FRANK J. PATELLA

National Marine Fisheries Service, Southeast Fisheries Center, Galveston Laboratory
4700 Avenue U, Galveston, Texas 77550, USA

Abstract.—The implementation of the Gulf of Mexico Shrimp Fishery Management Plan established an area commonly known as the Tortugas shrimp sanctuary and prohibited all trawling activity within that area between May 15, 1981, and April 15, 1983. Monthly commercial landing statistics of pink shrimp (*Penaeus duorarum*) were compared between the 2 years of the Tortugas sanctuary closure (i.e., 1981 and 1982), and these data also were compared with similar data from the historical fishery (1960-1979). Landings during the 23 years from 1960 through 1982 averaged 9.7 ± 1.8 million lb/year (mean \pm SD); average effort was 16,000 fishing-days/year. Catch per unit effort (CPUE) averaged 619 ± 76 lb/d for the 23 years, and ranged from 797 lb/d in 1980 down to 479 lb/d in 1982. No differences in catch, CPUE, or size composition were distinguishable due to the closure. However, compliance with the regulation by fishermen was poor.

The implementation of the Gulf of Mexico Shrimp Fishery Management Plan established an area commonly known as the Tortugas shrimp sanctuary (Figure 1) and prohibited all trawling activity within that area between May 15, 1981, and April 15, 1983 (GMFMC 1980). The basis for this regulation by the Gulf of Mexico Fishery Management Council (GMFMC) was founded on scientific information indicating that the sanctuary is a nursery area for the Tortugas pink shrimp stocks (*Penaeus duorarum*) and that recruitment to the offshore fishery depends on the sanctuary. Lindner (1965) and Berry (1970) utilized growth and mortality data to indicate that the yield of

pink shrimp would be greater if harvest were delayed until shrimp were larger than the minimum legal size (69 count, heads-off¹) for landing shrimp in Florida. The 1957 Florida legislature established an area on the Tortugas grounds that could be closed or open to shrimp trawling, and it specified a permanently closed nursery area in 1961. Florida only had jurisdiction out to 3 miles and was unable to enforce prohibition of trawling in much of the nursery area. Therefore, the concept

¹ The number of shrimp without heads that constitutes 1 lb.

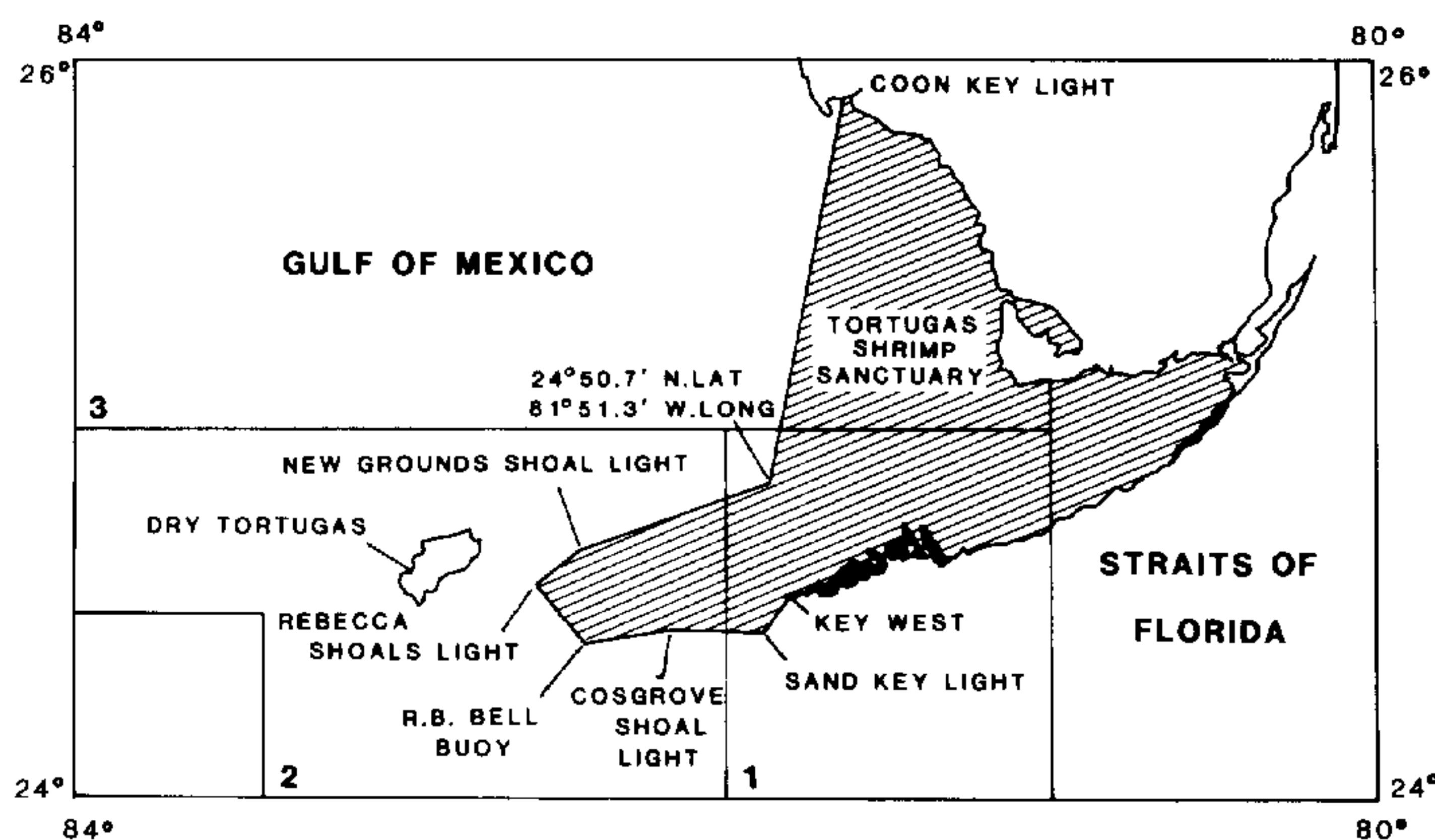


FIGURE 1.—Chart of the Dry Tortugas fishing grounds showing the Tortugas shrimp sanctuary and three statistical subareas.

of the GMFMC in establishing a permanent closure of the area, to be administered cooperatively by the State of Florida and the U.S. Department of Commerce, was to protect undersized pink shrimp from fishing. Furthermore, it was assumed that the distribution of small shrimp was confined mainly inside the sanctuary line and that shrimp outside the line were of legal size or larger. Thus, the establishment of a permanent sanctuary was projected to increase the annual fishery yield by about 1 million lb (GMFMC 1980).

The characteristics of the Tortugas fishery from the inception of the closure in May 1981 through April 1983 are reviewed in this report. Also, catch, effort, size composition of the landings, and catch per unit effort (CPUE) during the period of closure are compared with the historical data from 1960 through 1979. We determined whether or not these characteristics were affected by the regulations. This report is to be considered along with the reports by Roberts (1986, this issue) on details of the size distribution and abundance of pink shrimp from September 1981 to July 1983 and by Gitschlag (1986, this issue), on the movement of pink shrimp on the Tortugas fishing grounds.

Fishery Background

The Tortugas pink shrimp fishing grounds were discovered in 1949 and a major commercial shrimp fishery had developed by 1950. Regan et al. (1956) reported a decline in the landings of larger shrimp and possible depletion of the stock caused by landings of small shrimp (70 count and larger, heads off). Klima and Costello (1982) reviewed and summarized Florida regulations on the pink shrimp fishery from 1955 to the present. They identified Florida's concerns about possible over-exploitation and the concern over large catches of very small, unusable pink shrimp that were probably discarded at sea. To prevent wastage and discard of small shrimp, the Florida State Board of Conservation specified the minimum legal size of mesh allowed in the codends of shrimp trawls on the Tortugas grounds and established a minimum size limit for shrimp.

In its 1957 session, the Florida legislature passed a law designating part of the Tortugas fishing grounds a "controlled area": i.e., an area that could be closed or opened to shrimp trawling as appropriate. This "controlled area" was the forerunner of the present sanctuary (a sanctuary in various geographic forms has been in effect from 1957 to the present). The decision to open or close the controlled area was based on monitoring, by state

research staff, of the sizes of shrimp occurring in the area. When shrimp were predominantly smaller than 50 count (heads off), the area was to be closed to trawling. The Florida legislature modified the controlled area in 1961, specifying one part to be permanently closed as a "nursery area." The remainder was designated as a controlled area to be opened or closed as appropriate based on sizes of shrimp in that area. Caillouet and Koi (1981) explored the causes of annual fluctuations in size composition of the reported catches from 1960 to 1978, but they could not determine whether or not observed shifts in size composition were related to changes in fishing regulations.

The Tortugas Fishery

The Tortugas pink shrimp fishery is a year-around nocturnal fishery of about 400 to 600 gulf-type trawlers. Otter trawls are fished in waters usually deeper than 10 fathoms and at least 5 miles from land. The principal fishery grounds are within 60 miles of Key West.

Fishing is restricted mainly to subarea 2 because of loggerhead sponges, coral, and other obstructions in adjacent areas (Iversen et al. 1960). Since 1975, fishing effort has generally increased in subareas 1 and 3 as fishermen gained more knowledge of trawlable bottom and the use of better navigation equipment (Loran C and plotters).

The major fishing season in the Tortugas runs from October through May of each year. During the summer months, the majority of the Tortugas fleet migrates to the northern Gulf, where some Florida dealers open packing houses for their established fleets (Ernest Snell, FIMD², Miami, personal communication). These trawlers return to the southern area by late October to again fish the Tortugas grounds.

Major changes in the fleet have been the addition of "quad-rigs" or "twin trawls" in 1979 and the use of freezer holds. Approximately 90% of the vessels with 350-horsepower engines now use quad-rigs, whereas only 60% with less than 350 horsepower are so equipped. The use of freezer holds by some trawlers began in 1968. Approximately 50–100 freezer trawlers from the northern Gulf ports normally fish Tortugas during January through April (Edward Little, FIMD, Key West, personal communication). These vessels tend to harvest large quantities of small shrimp, which are

² Fishery Information Management Division of the Southeast Fisheries Center (SEFC), National Marine Fisheries Service (NMFS).

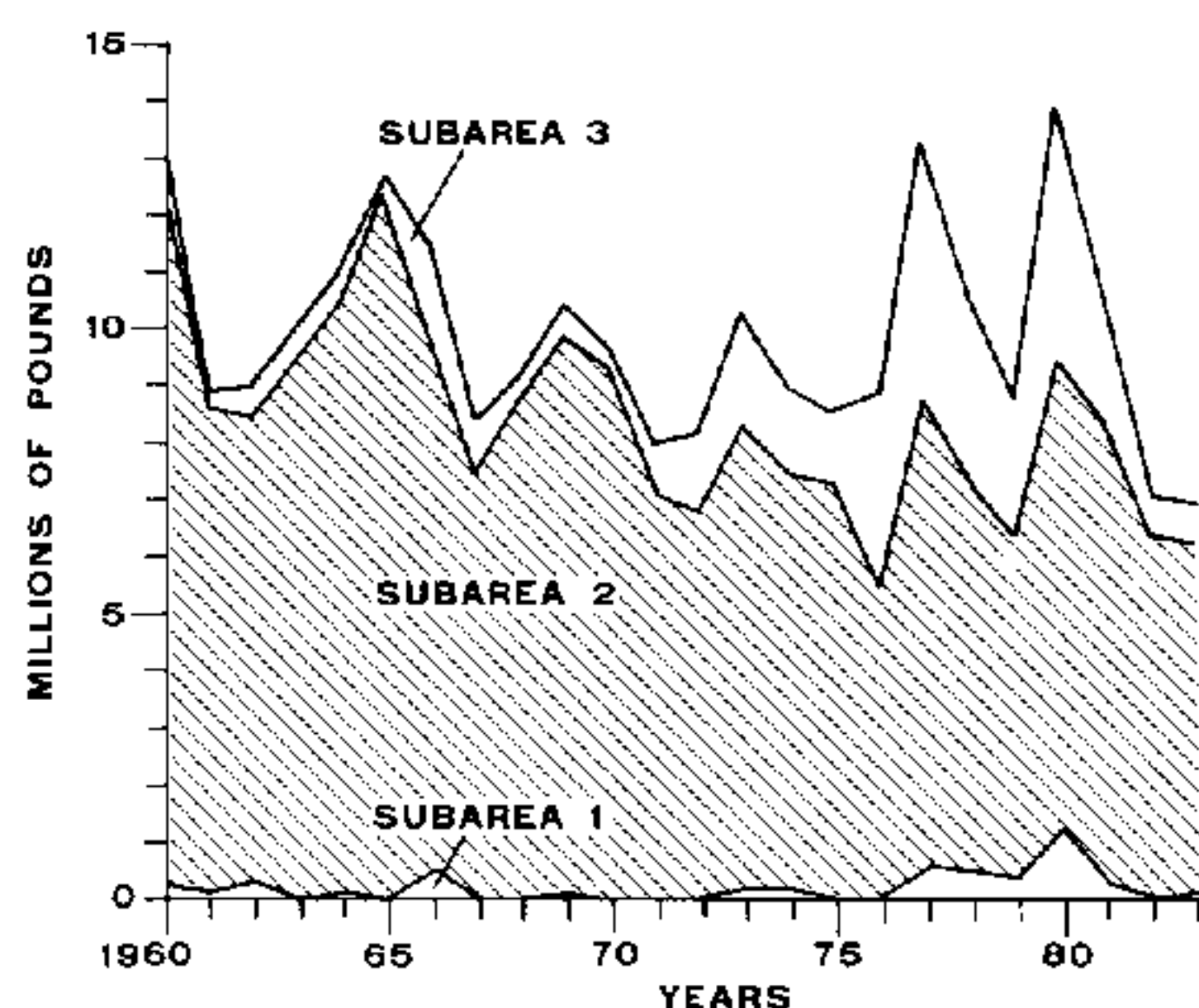


FIGURE 2.—Cumulative landings by biological years 1960–1983 (May 1960–April 1984) of pink shrimp from three subareas of the Tortugas fishing grounds.

landed heads-on. Fishing grounds that were unusually productive for small shrimp were put off limits by the establishment of the Tortugas shrimp sanctuary in May 1981.

Since 1960, landings by the Tortugas pink shrimp fishery have always been greatest from subarea 2; however, during the past decade there have been significant changes in areas fished (Figure 2). Annual landings in subarea 2 have decreased from 92% during the 1960–1971 years to 79% from 1972 through 1975 and to only 64% from 1976 through 1979. Simultaneously, fishing in subarea 3 has increased from 7 to 17% in 1972, and to 33% in the 1976–1979 period. The shrimping grounds have expanded from the inception of the fishery to include areas farther to the north and south of Key West as continued trawling cleared the grounds of loggerhead sponge and coral. Almost 4.5 million lb of shrimp were landed in 1980 from subareas 1 and 3, whereas only about 0.3 and 0.1 million lb were landed from these subareas in 1960.

Since the implementation of the closed area in May 1981, fewer pink shrimp have been caught in subareas 1 and 3. During October 1981–January 1982, most of the catch came from subarea 2 from depth zones 11–15 and 16–20 fathoms. Harvests from subarea 2 were low from February 1982 to March 1983, then increased in March and April 1983.

Methods

Sources of fishery data.—Collections of detailed catch statistics describing the Gulf of Mexico shrimp fishery in United States waters since 1956 are available and the procedures used to collect

them have been described by Klima (1980). The statistics compiled by FIMD–SEFC were used to determine the effects on the fishery of the Tortugas shrimp sanctuary. Catch and effort statistics were grouped and analyzed by “biological years” (May–April) for ease of comparing the historical data with data from the closed-sanctuary period of May 1981–April 1983. The statistics consisted of catch by statistical subarea (Figure 1) fishing effort (in units of 24 h actual fishing time, expressed as days fished), and size composition of the catch in eight size groupings. Locations and amount of fishing effort expended in 24 h were obtained by interviewing vessel captains at the end of their trips. Brunenmeister (1984) indicated that fishing power of Gulf of Mexico shrimp vessels increased about 20% from 1965 to 1977. Nominal fishing effort was used in this study because data were not available after 1977 nor before 1965 to standardize fishing effort. Generally, an interview level of about 30% has been obtained except at times when the NMFS conducted special studies (Berry 1967; Gitschlag 1986).

All catch data were recorded as pounds of decapitated shrimp by species, size category, statistical subarea, depth zone, and month. Size composition of the reported catches was examined in units of pounds caught in eight “count” or size categories representing number of shrimp per pound with heads off (<15, 15–20, 21–25, 26–30, 31–40, 41–50, 51–67, ≥68). The weighted average number of shrimp per pound was calculated by multiplying the pounds landed in each of the size categories by the respective size grouping. Catch and effort data used to compile CPUE (pounds per 24 h of fishing) were reported in Fishery Statistics of the United States (NMFS 1982a) and in Shrimp Landings (NMFS 1982b). Fishing effort for 1980 is only a crude estimate due to major changes in the way effort was recorded. This problem was rectified in 1981 so that, except for 1980, procedures for estimating effort are consistent for the entire data set (1960–1983). Data from 1981 to the present are on file at the FIMD–SEFC office and are available for inspection. Ernest Snell (FIMD–SEFC) provided specific information concerning the Tortugas shrimp fishery relative to fleet activities, changes in the fleet, number of trips, discards, and specifics of catch and effort for the fishing area during 1981–1983.

Statistical tests.—Catch data frequently follow skewed distributions, show heteroscedasticity, and have nonadditive components. Transformations applied to the original data often alleviate these

problems and permit valid statistical analysis by Student's *t*-tests or two-way analyses of variance (Sokal and Rohlf 1969). Taylor's (1961) test of relationships between means and variances showed that pink shrimp catch data should be transformed logarithmically and that CPUE data should be transformed by the inverse of the square root. The analysis of these transformed data provided statistical support to what one could visually determine for the untransformed data. All summaries are presented with untransformed data.

Mean monthly catches, fishing effort, and mean CPUEs for the 1960–1979 historical period were compared with the respective 1981–1983 monthly data via two-way analyses of variance. Additional comparisons between monthly means of the fisheries data for the five earliest years (1960–1964), the five latest years (1975–1979), and the 1981–1983 monthly data were made by paired *t*-tests. Pink shrimp size distributions for each month were compared with each of the three historical data sets and the 1981–1983 monthly size distributions with *G*-tests (Sokal and Rohlf 1969). Unless otherwise stated, tests of significance were performed at the 95% level of confidence ($P = 0.05$; Rohlf and Sokal 1969).

Results

Landings

Annual landings by biological years 1960–1982 (May 1960 to April 1983), in subareas 1–3 averaged approximately 9.7 million lb (Figure 3). They fluctuated from a high of slightly less than 13.4 million lb in 1960 to a low of about 7 million lb

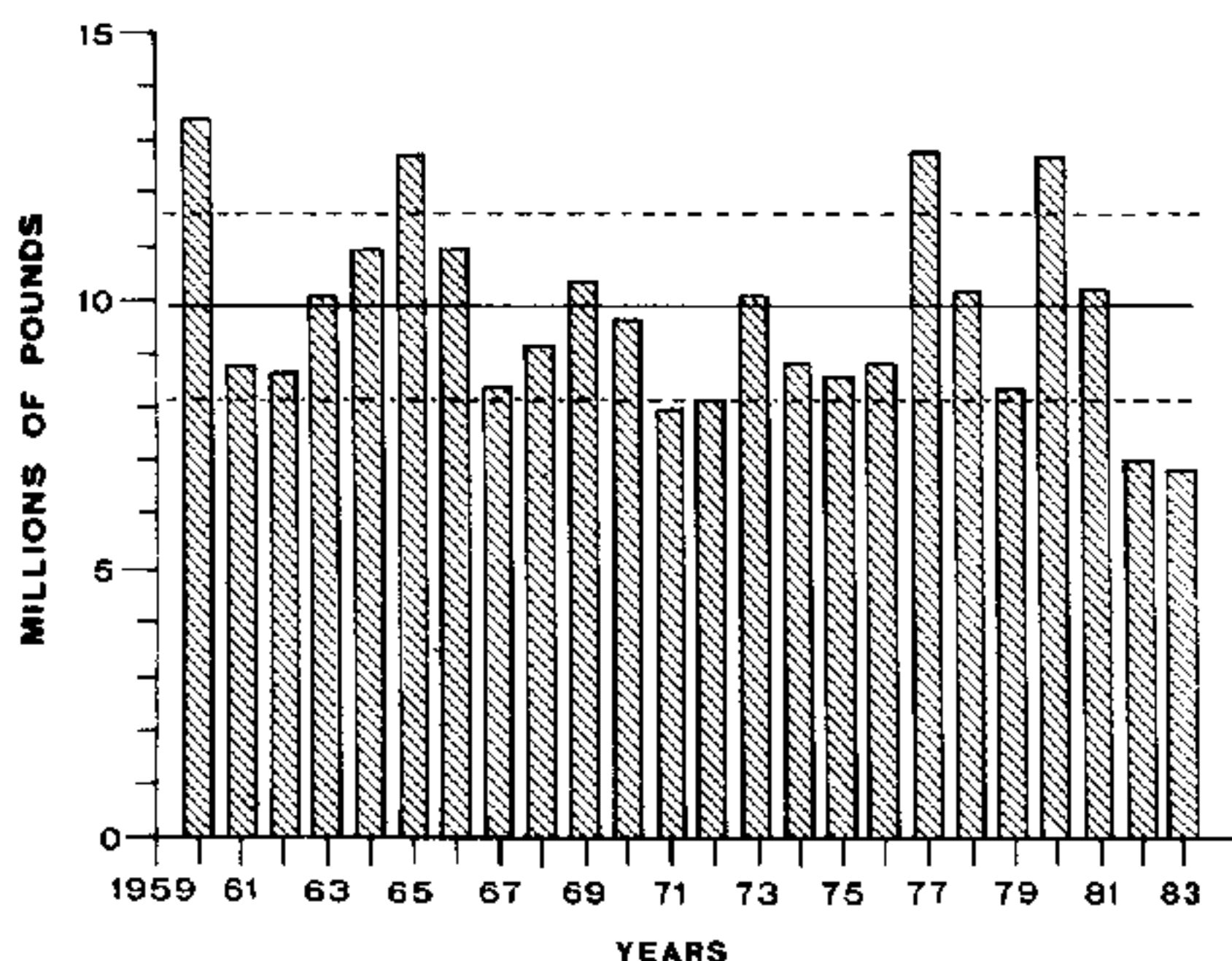


FIGURE 3.—Annual pink shrimp landings from the Tortugas fishing grounds (subareas 1–3) by biological years 1960–1983. The solid line is the mean; each broken line is 1 SD from the mean.

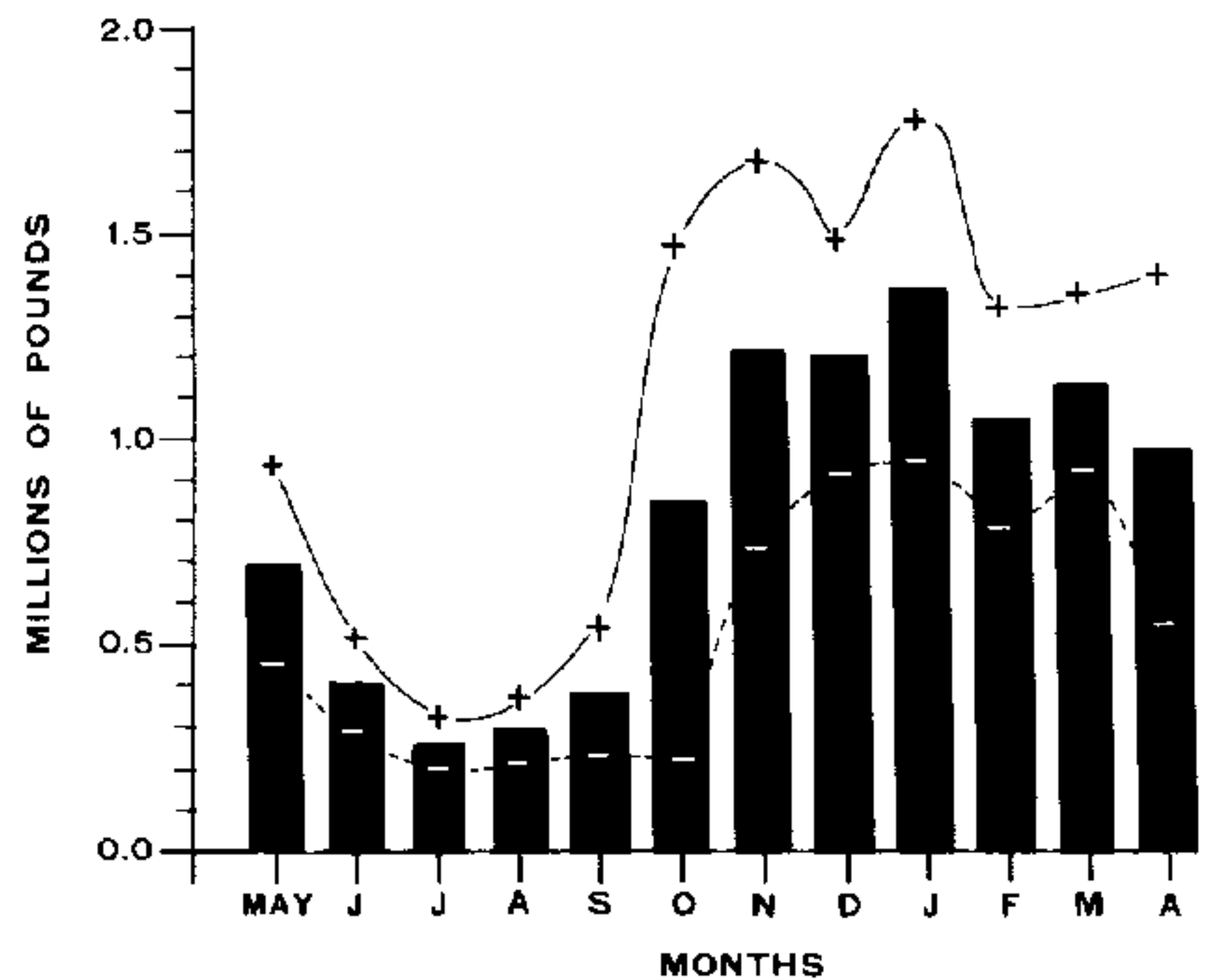


FIGURE 4.—Monthly means of pink shrimp landings from the Tortugas fishing grounds (subareas 1–3) for biological years 1960–1979. Each + and – indicates 1 SD from the monthly mean.

in 1982 (and were slightly lower still in 1983). The small variation in annual landings (SD, ± 1.8 million lb; coefficient of variation, CV = SD/mean, 18.0%) indicated there was a relatively stable fishery throughout this 23-year period. Only during 1960, 1965, 1971, 1972, 1977, 1980, and 1982 (and again in 1983) did landings fall outside 1 SD from the mean. The 1981 pink shrimp catch of 10.2 million lb was slightly larger than, but not significantly different from, the historical average of 9.8 million lb for 1960–1979 but was significantly larger than the 1982 catch of 7.0 million lb ($P < 0.01$).

The average monthly landings for 1960–1979 showed an annual cycle with an amplitude that ranged from a high of 1.3 million lb in January to a low of less than 0.3 million lb in July (Figure 4). The monthly pattern of pink shrimp landings in both the 1981 and 1982 biological years was substantially different from the historical pattern (Figure 5). Compared with the monthly historical means, the landings in 1981 were significantly greater ($P < 0.01$) for May through July and continued to be above the historical averages in August and September. Landings for October were average but landings for the other months of the 1981 biological year were below normal, particularly during February, March, and April 1982. Below-average landings carried into the 1982 biological year for May and June. Landings for July 1982 were average but were slightly above normal in August. The large fall harvest, typical of the historical data, was definitely missing in 1982, the

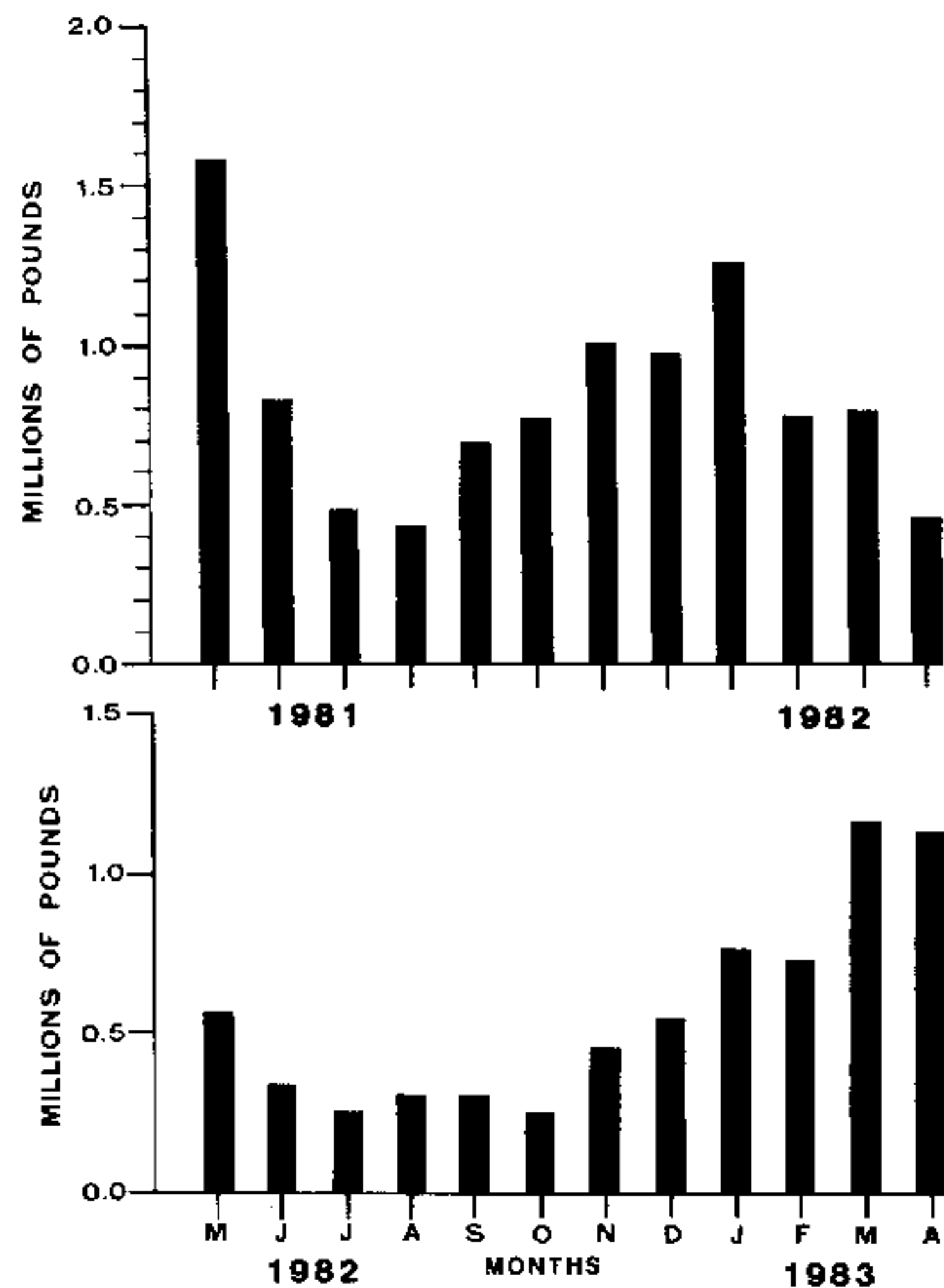


FIGURE 5.—Monthly pink shrimp landings from May 1981 through April 1983 (biological years 1981, above, and 1982, below) from the Tortugas fishing grounds (sub-areas 1–3).

difference in November being substantial and that in December being statistically lower. Not until March 1983 did the monthly landings for biological year 1982 reach the historical average. We noted highly significant differences ($P < 0.01$) between both 1981 and 1982 monthly landings and the historical monthly landings for 1960–1979, as well as differences in the monthly landings between 1981 and 1982 ($P < 0.05$).

Monthly landings both for the first 5 and the last 5 years of the 1960–1979 period were compared with each of the two closure years, 1981 and 1982. Analysis of variance revealed no significant differences between the 1960–1964 or the 1975–1979 landings and the 1981 annual landings, although significant differences in the landings between months were found for both comparisons ($P < 0.05$). On the other hand, comparisons of 1982 with the first 5 years and with the last 5 years of the fishery yielded significant differences between years as well as between months ($P < 0.05$). Pink shrimp production in 1982 was poor and below both the historical average annual and monthly landings for the first and the last 5 years in the fishery. The 1981 annual landings were slightly above the average year, but not signifi-

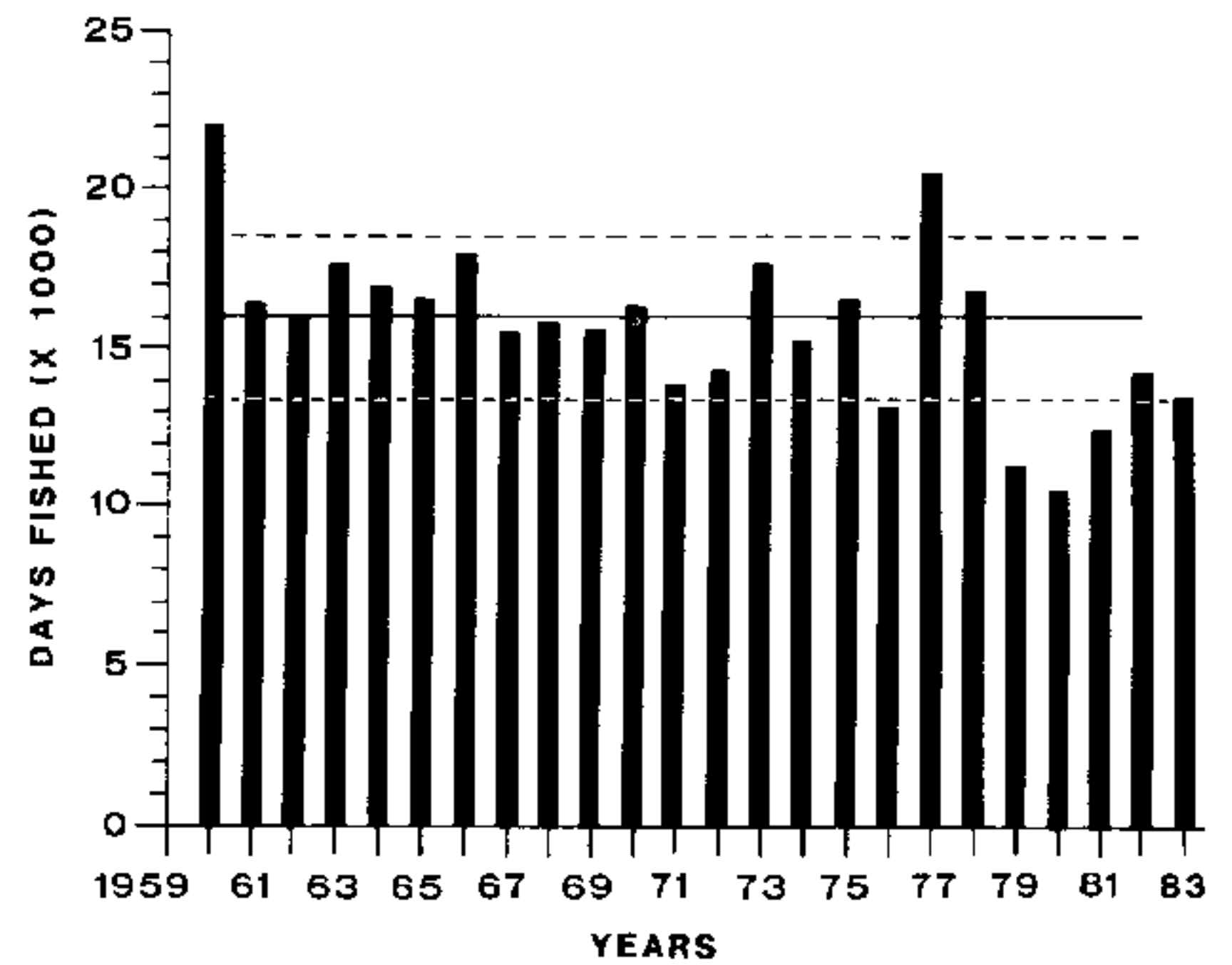


FIGURE 6.—Fishing effort for pink shrimp on the Tortugas fishing grounds (subareas 1–3) by biological years for 1960–1983. The solid line is the mean effort; broken lines mark ± 1 SD.

cantly different from the first or last 5 years' average annual landings.

Fishing Effort

Fishing effort from 1960 to 1982 averaged approximately 16,000 d/year with a standard deviation of $\pm 2,500$ d and a 15.6% coefficient of variation. Highest fishing effort was 22,000 d expended in biological year 1960 (Figure 6); the lowest effort was 10,900 d expended in 1980. Fishing effort did not fluctuate greatly throughout these 23 years. However, there was a slight decrease in effort from 1978 through 1981. The average fishing effort is a relatively good indicator of the constancy of this fishery.

Fishing effort during the closure period was 12,800 and 14,700 d in 1981 and 1982, respectively—lower than the historical average. The average fishing effort by month for 1960 through 1979 followed the monthly landing patterns and showed an annual cyclic pattern, rising from a low in July–September to a peak in January–March, then declining again (Figure 7). Fishing effort in the first closure year, 1981, was relatively low and fluctuated considerably from month to month (Figure 8). No smooth cyclic pattern was apparent. In contrast, 1982 fishing effort was low from May through September, gradually increased to a peak in January of approximately 2,000 d, and remained at this level through April of 1983. Two-way analysis of variance showed statistical differences between each of the closure years and the historical year-group 1960–1979 ($P < 0.01$); monthly fishing effort was generally lower in 1981

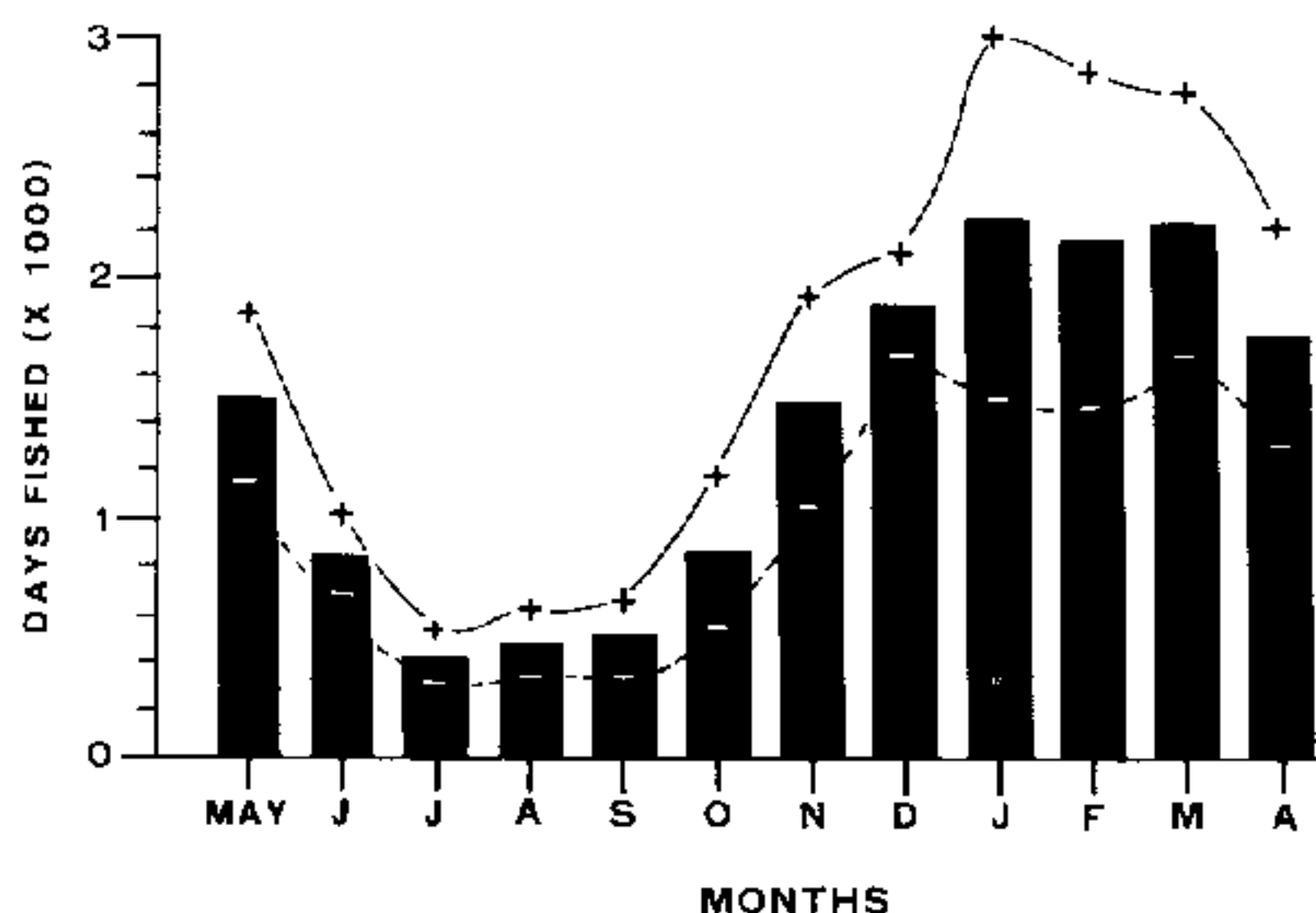


FIGURE 7.—Monthly means for pink shrimp fishing effort on the Tortugas fishing grounds, 1960–1979. Each + and – indicates 1 SD from the monthly mean.

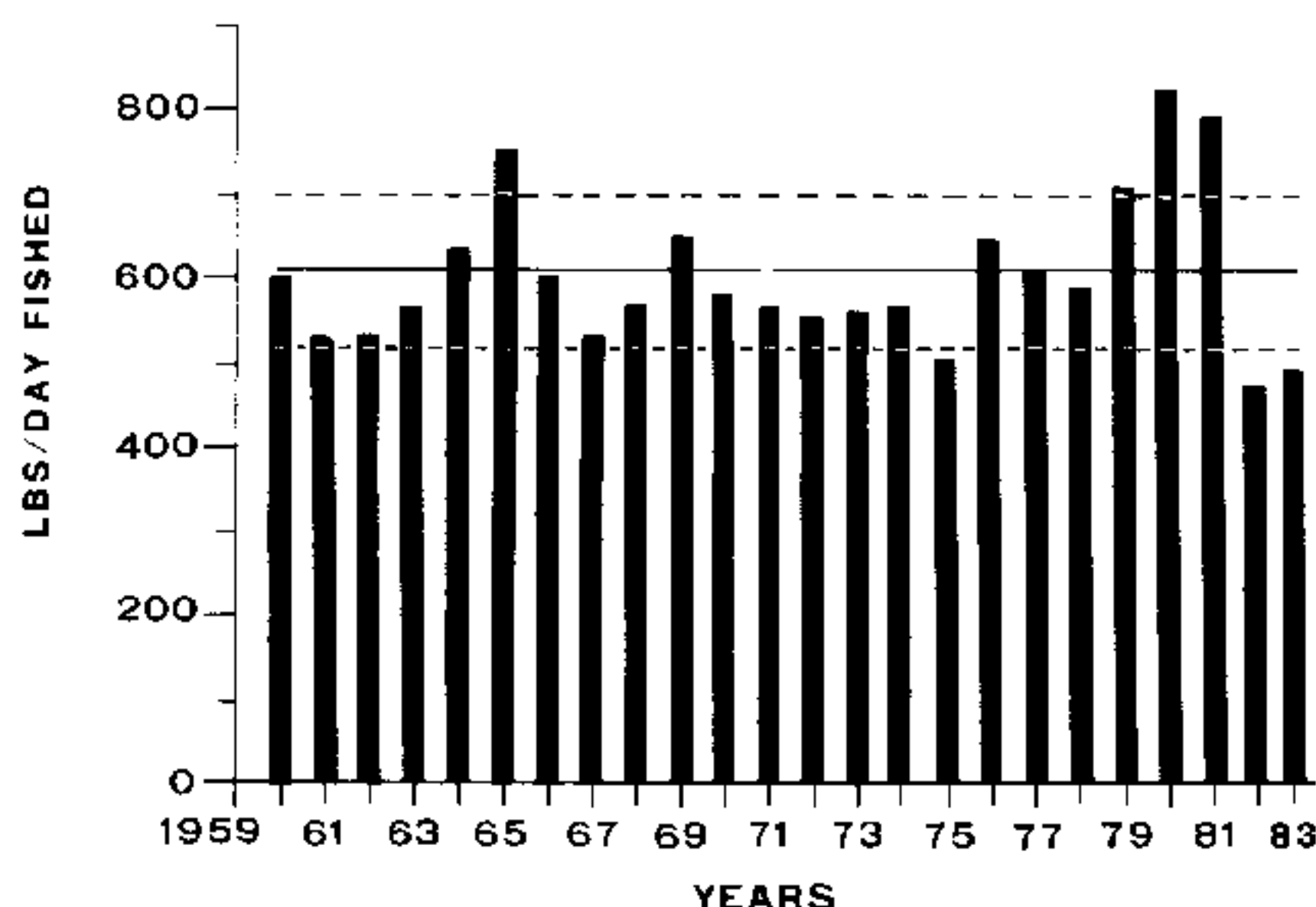


FIGURE 9.—Catch per unit effort of pink shrimp (subareas 1–3) in biological years 1960–1983 (solid line is the mean, broken lines are ± 1 SD).

and 1982 than during 1960–1979. Differences in monthly effort among 1960–1979, 1981, and 1982 periods are graphically evident.

Relative Abundance

The relative abundance of pink shrimp, as expressed by catch per unit effort (CPUE), is reported as pounds caught for 24-h fishing day (lb/d). For the Tortugas fishing grounds, the annual CPUE (the mean of 12 monthly CPUEs) has been remarkably stable from 1960 through 1982 (Figure

9), averaging 619 lb/d (SD = 79 lb; CV = 13%). The highest annual CPUE was 797 lb/d recorded for 1980 and the lowest was 479 lb/d recorded for 1982. Both of these extremes were significantly different from the historical years (1960–1979) when tested by the *t*-test of two means ($P < 0.01$).

The uniformity of the annual average CPUEs is somewhat misleading as there were large variations in the monthly CPUEs throughout each biological year, which cycled from a low average around 500 lb/d in May and June to highs over 800 lb/d in September–November during 1960–1979 (Figure 10). With the closure of the sanctuary area to trawling in May 1981, the monthly CPUE, which had been unusually high that month (greater than 1,200 lb/d, dropped to around 700 lb/d and remained at that level through September. A “spike” occurred in October at 1,400 lb/d, but the CPUE dropped to about 600 lb/d in November, rose again in December to about 1,400 lb/d, and then gradually declined to about 400 lb/d by April (Figure 11). During the 1981 biological year, the CPUE fluctuated radically whereas it was much steadier the next year, averaging approximately 478 lb throughout the period. Ratios of the monthly CPUEs in 1981 and 1982 to those of the historical 1960–1979 period revealed a higher relative abundance of pink shrimp on the grounds than the historical norm in 1981, but a lower relative abundance in 1982 (Figure 12). Two-way analysis of variance indicated that there were significant differences between 1981 and the historical CPUEs with respect to both years and months ($P < 0.01$), whereas 1982 values differed from historical ones with respect to years ($P < 0.01$) but not months. In comparing 1981 with 1982, there

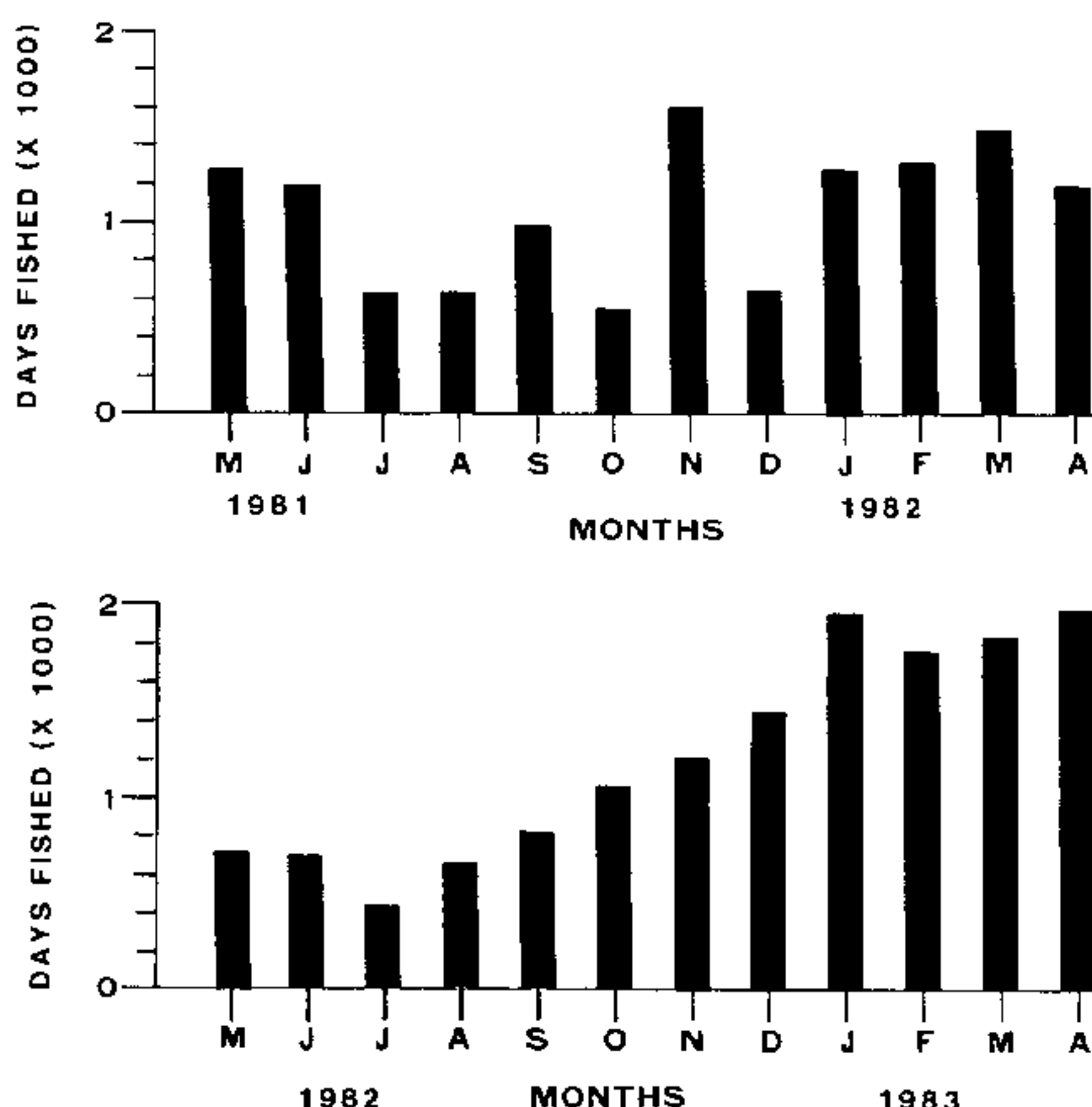


FIGURE 8.—Monthly means of pink shrimp fishing effort for May 1981 through April 1983 (biological years 1981, above, and 1982, below) for the Tortugas grounds (subareas 1–3).

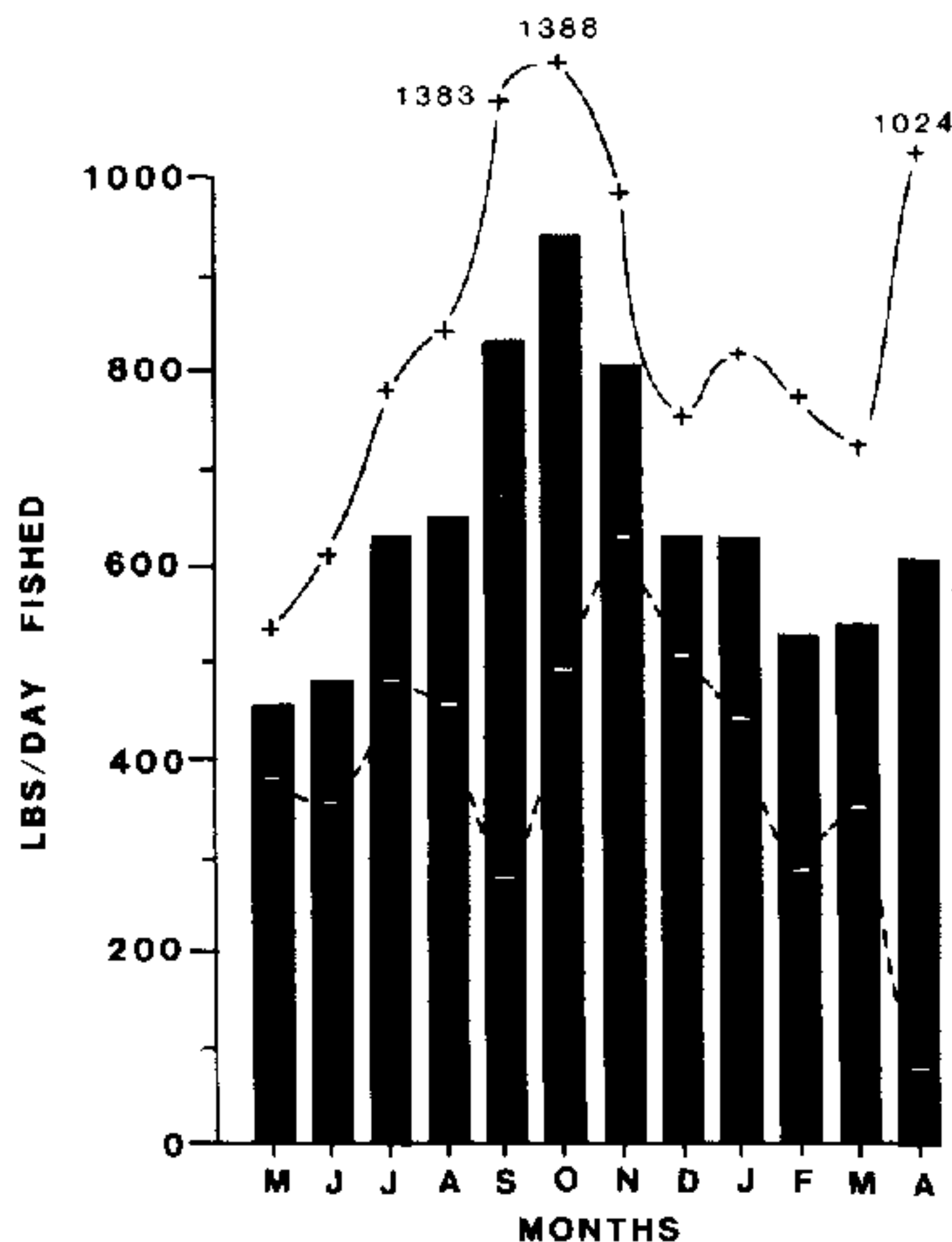


FIGURE 10.—Monthly means of pink shrimp catch per unit effort on the Tortugas grounds (subareas 1–3) for biological years 1960–1979. Each + and – indicates 1 SD from the monthly mean.

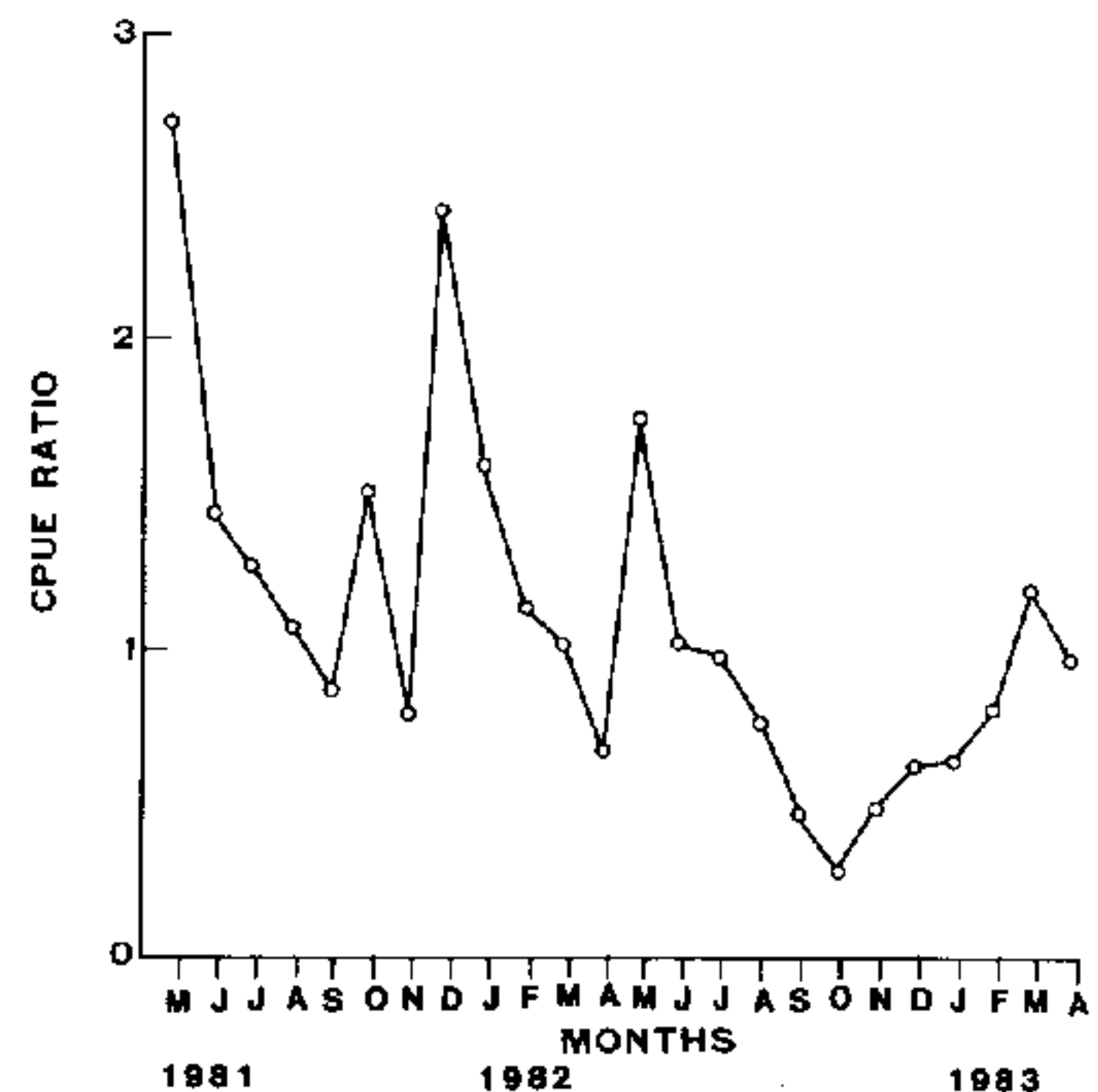


FIGURE 12.—Ratios of monthly catch per unit effort during biological years 1981–1982 to their corresponding historical means (1960–1979) for the Tortugas pink shrimp fishery (subareas 1–3).

were significant differences between years ($P < 0.05$) and between some months (evident in Figure 12).

Size of Pink Shrimp

Recruitment of pink shrimp into the Tortugas fishing grounds occurs in two periods during the year. The first recruitment usually occurs from August through October, the second from March through May. The pounds of pink shrimp landed and the average size of pink shrimp (measured by the size categories of FIMD) have been used as indicators of recruitment on the Tortugas grounds. Specifically, if the landings for a given month exceeded the historical average for 1960–1979 and if the average weighted mean size for that month was greater than the historical average, we called recruitment “good” or “better than average” for that month. The pluses on Table 1 indicate periods when recruitment was strong according to these criteria. Good recruitment in two or more successive months occurred in the fall of calendar years 1960, 1961, 1964, 1965, 1966, and 1979 and in the spring in 1963, 1970, 1978, 1981, and 1983. Good recruitment appears to have been more common in the spring months since 1977, whereas it was more common in the fall of the early 1960s.

In March and April 1981, before the closure, there was a large movement of small pink shrimp onto the Tortugas grounds. Apparently there was no major movement of small shrimp onto the fishery grounds from then until March and April 1983.

The size of pink shrimp landed may be used to

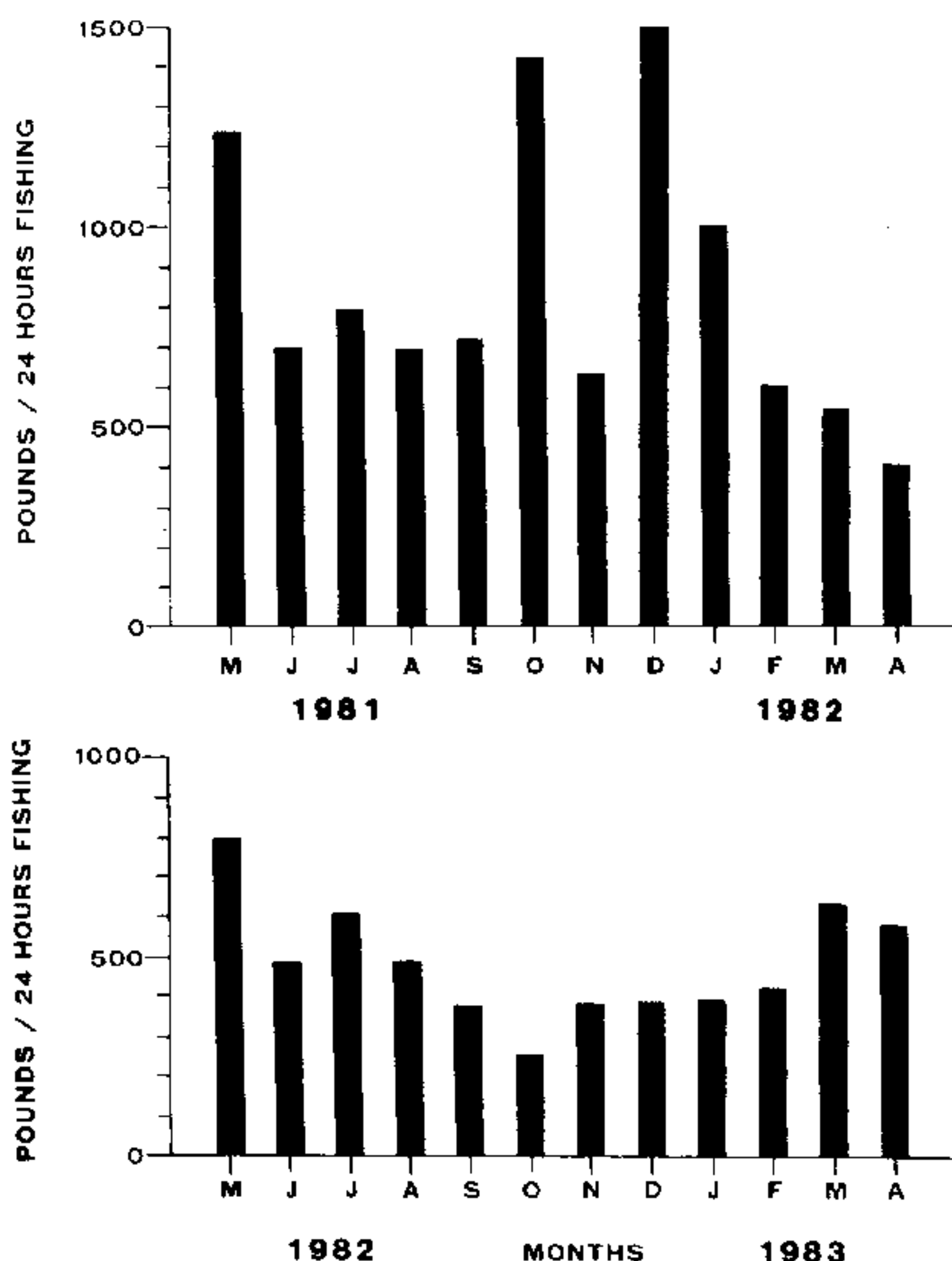


FIGURE 11.—Monthly means of pink shrimp catch per unit effort for May 1981–April 1983 (biological years 1981, above, and 1982, below) for the Tortugas grounds (subareas 1–3).

TABLE 1.—Monthly index of pink shrimp recruitment on the Tortugas fishery grounds, based on average weight, size count, and commercial landings. A plus indicates better than average recruitment.

Biological year ^a	Mar	Apr	May	Aug	Sep	Oct	Nov
1960			+	+	+	+	
1961	+			+	+	+	+
1962							
1963	-	+					
1964				+	+		
1965				+	-	+	+
1966				+	+	+	+
1967							
1968					+		
1969							
1970	+	+	+				
1971							
1972							
1973				+			
1974							
1975				+			
1976							
1977		+					
1978	+	+	+				
1979				+	+		
1980					+		
1981	+	+	+				
1982				+			
1983	+	+					

^a May through April.

identify changes that may have occurred due to fishing. If prohibition of trawling in the sanctuary was effective and restricted the capture of small shrimp, we would expect the size of shrimp to have increased above historical averages. Using a *G*-test, we compared the percent size distribution of the

TABLE 2.—The *G*-values resulting from comparisons of pink shrimp sizes in landings by the Tortugas fishery (subareas 1–3) during years of sanctuary closure (1981 and 1982 biological years) and during previous years. Asterisks (*) indicate significant *G*-values ($P < 0.05$).

Month	1981 versus		1982 versus		1981 versus 1982
	1975–1979	1960–1964	1975–1979	1960–1964	
May	68.5*	48.7*	49.7*	7.9	47.2*
Jun	41.8*	51.8*	20.4*	4.1	53.0*
Jul	54.7*	47.1*	9.6	23.4*	73.2*
Aug	55.3*	57.6*	88.6*	51.1*	171.9*
Sep	12.6*	19.4*	22.7*	6.8	12.5
Oct	21.0*	50.0*	36.0*	33.2*	30.9*
Nov	19.6*	52.0*	22.5*	30.1*	13.3*
Dec	20.9*	18.7*	13.8*	29.5*	21.8*
Jan	16.1*	16.0*	7.4	22.2*	35.5*
Feb	5.1	29.1*	13.9*	30.5*	20.7*
Mar	16.2*	24.4*	52.9*	28.5*	37.5*
Apr	27.2*	7.2	25.5*	2.4	11.7

TABLE 3.—Monthly average weighted numbers of pink shrimp per pound (heads off) for the historical 1960–1979 (\pm SD), 1981, and 1982 biological years^a in the Tortugas fishery. A plus sign (+) indicates larger shrimp (smaller size group on a per-pound basis) and a minus sign (–) indicates smaller shrimp than the historical average.

Month	1960–1979	1981	1982
May	46.8 \pm 5.1	57.4 –	48.4 –
Jun	45.2 \pm 4.5	52.7 –	45.7 –
Jul	44.0 \pm 4.7	44.2 –	36.6 +
Aug	44.0 \pm 7.7	38.9 +	55.0 –
Sep	48.7 \pm 7.9	47.5 +	49.0 –
Oct	47.9 \pm 4.8	41.4 +	43.3 +
Nov	43.1 \pm 3.3	36.4 +	41.3 +
Dec	40.2 \pm 2.8	34.9 +	39.3 +
Jan	40.2 \pm 3.1	35.6 +	43.6 –
Feb	42.7 \pm 3.1	42.1 +	48.0 –
Mar	47.5 \pm 4.4	46.8 +	57.5 –
Apr	48.3 \pm 5.8	49.8 –	54.1 –

^a May through April.

commercial pink shrimp landings by month in the two closure years, 1981 and 1982, with the 1960–1964 and 1975–1979 data on size composition (Table 2). These data showed that for 12 of the 24 months of restricted fishing, the average size was larger than the historical sizes (Table 3). Furthermore, little similarity was noted between monthly size composition for any of the groupings tested. Significant differences between 1981 and 1982 also were observed for all months except September and April.

Paired tests indicated significant differences in monthly mean sizes between 1981 and the historical period (1960–1979), but not between 1982 and the historical period or between 1981 and 1982 (Table 2). The ratio of mean monthly sizes from biological year 1981 to the historical mean sizes show that the landings of pink shrimp did not show a consistent increase in average size of the shrimp as would be expected if the management measures were effective (Figure 13).

Catch versus Fishing Effort

We examined the landings in millions of pounds versus total fishery effort for biological years 1960 through 1983 (Figure 14). These data provide an indication of the condition of the fishery. A few years stand out—1960, 1965, 1977, and 1980—when high landings occurred at various levels of fishing effort. The 1981 landings were high with relatively low fishing effort, whereas 1982 and 1983 landings were low with moderate levels of fishing effort.

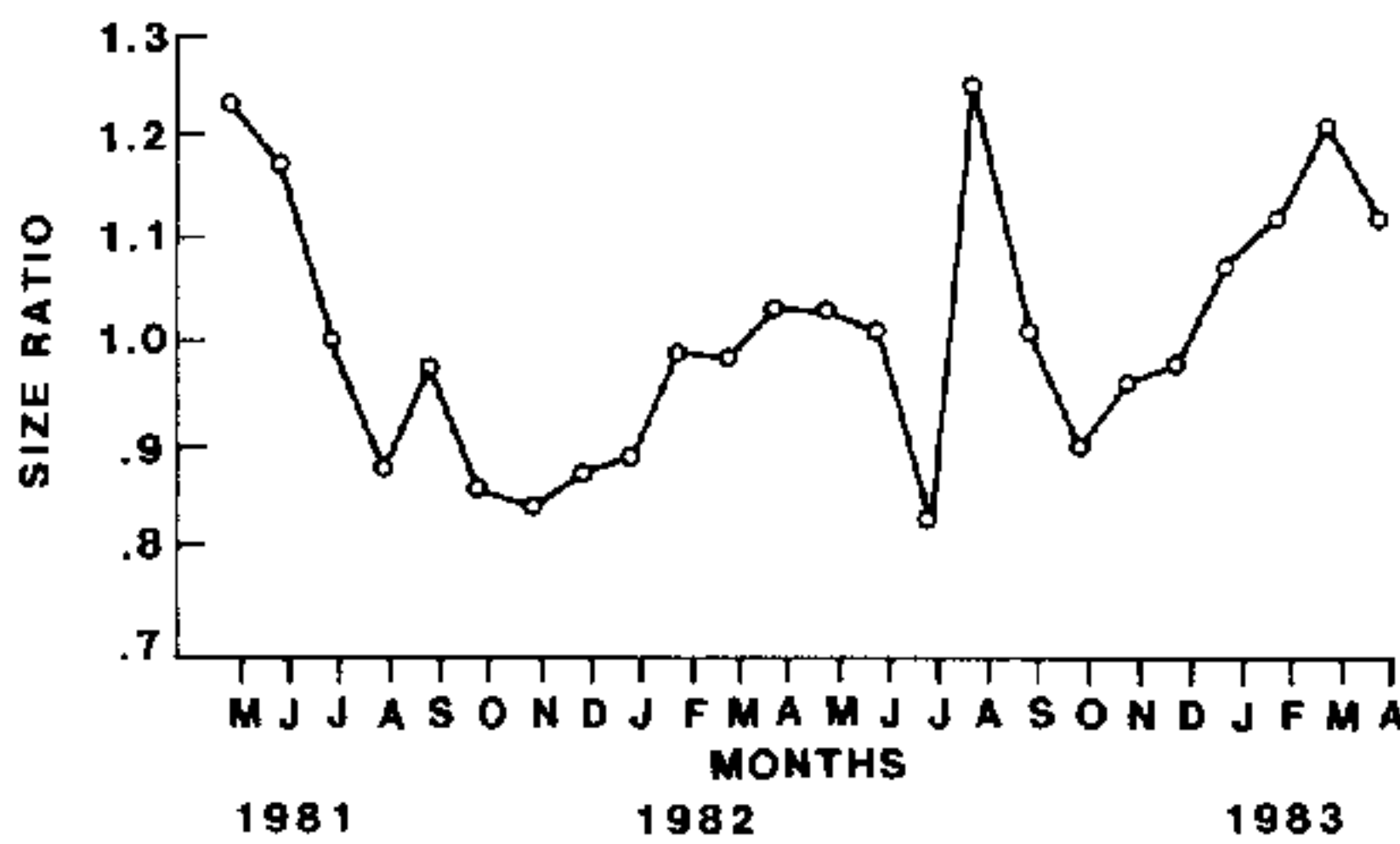


FIGURE 13.—Ratios of monthly mean number of pink shrimp per pound for May 1981–April 1983 (biological years 1981 and 1982) to monthly mean number of pink shrimp per pound for 1960–1979 in landings by the Tortugas fishery. Low ratios mean relatively larger shrimp in 1981–1983.

Discussion

The Tortugas sanctuary was established in May 1981. In evaluating the management regulations, we have specifically looked at landings, effort, CPUE, and size composition from May 1981 through April 1983 and compared these data with the historical data from 1960 through 1979. Historically, the recruitment of small pink shrimp onto the Tortugas grounds occurs between September and November but in certain years there is also a major spring recruitment. Just prior to the May closure of the sanctuary, in March and April of 1981, there was good recruitment of small shrimp onto the Tortugas grounds. That recruitment continued through May, and this recruitment

sustained the fishery through 1981. The catch amounted to 10.2 million lb in 1981. However, there was no strong recruitment onto the Tortugas grounds again until March and April of 1983. Consequently, the fishery in 1982 produced an all-time low of approximately 7 million lb of pink shrimp. It would appear at the outset that the fishery had collapsed, but the collapse was due primarily to limited recruitment of small juveniles onto the grounds.

The Tortugas fishery has been very stable and does not fluctuate greatly from year to year; annual production averages about 9.8 million lb. The fishery is bounded naturally by untrawlable bottoms of loggerhead sponges and coral reefs, where pink shrimp are protected from trawling even though they may be present in high concentrations. The large area of untrawlable bottom surrounding the fishery grounds may be the reason why this fishery has been so stable throughout its existence. The 1982 fishery was definitely an exception to this stable trend: both landings and CPUE were lower than in any other year. Historically, the CPUE has averaged 619 lb/d; there was an all-time low of 479 lb/d in 1982 and an all-time high of 797 lb/d in 1981. The tone of the fishery in both years was set by the amount of recruitment. With good recruitment in March–April 1981, the stage was set for a good fishery, whereas the lack of recruitment in 1982 resulted in a devastatingly low fishery throughout the rest of the year.

Evaluation of the impact of the sanctuary area on these catches and catch rates cannot be made readily because there were 34 violations of fishing in the closed area and a compliance of only 65%, as reported by C. Fuss (NMFS Enforcement Office statistics). If a substantial amount of fishing effort were expended in the sanctuary, it would be virtually impossible to make a valid evaluation of the impact of the closed area. From the lack of compliance by the fishermen and the number of violations both in 1981 and 1982, it is apparent that the theoretical increase in yield of 1 million lb could not be realized.

In examining the size distribution of the commercial catch, it was apparent that the average monthly size was different between the 1981 and preclosure years. No difference was observed in the 1981 and 1982 average sizes, however. It should be noted that there was a large variation in the average size between months and between years. When we compared the monthly size composition of the eight size groups, we observed little similarity between 1981 and 1982 and between 1960–

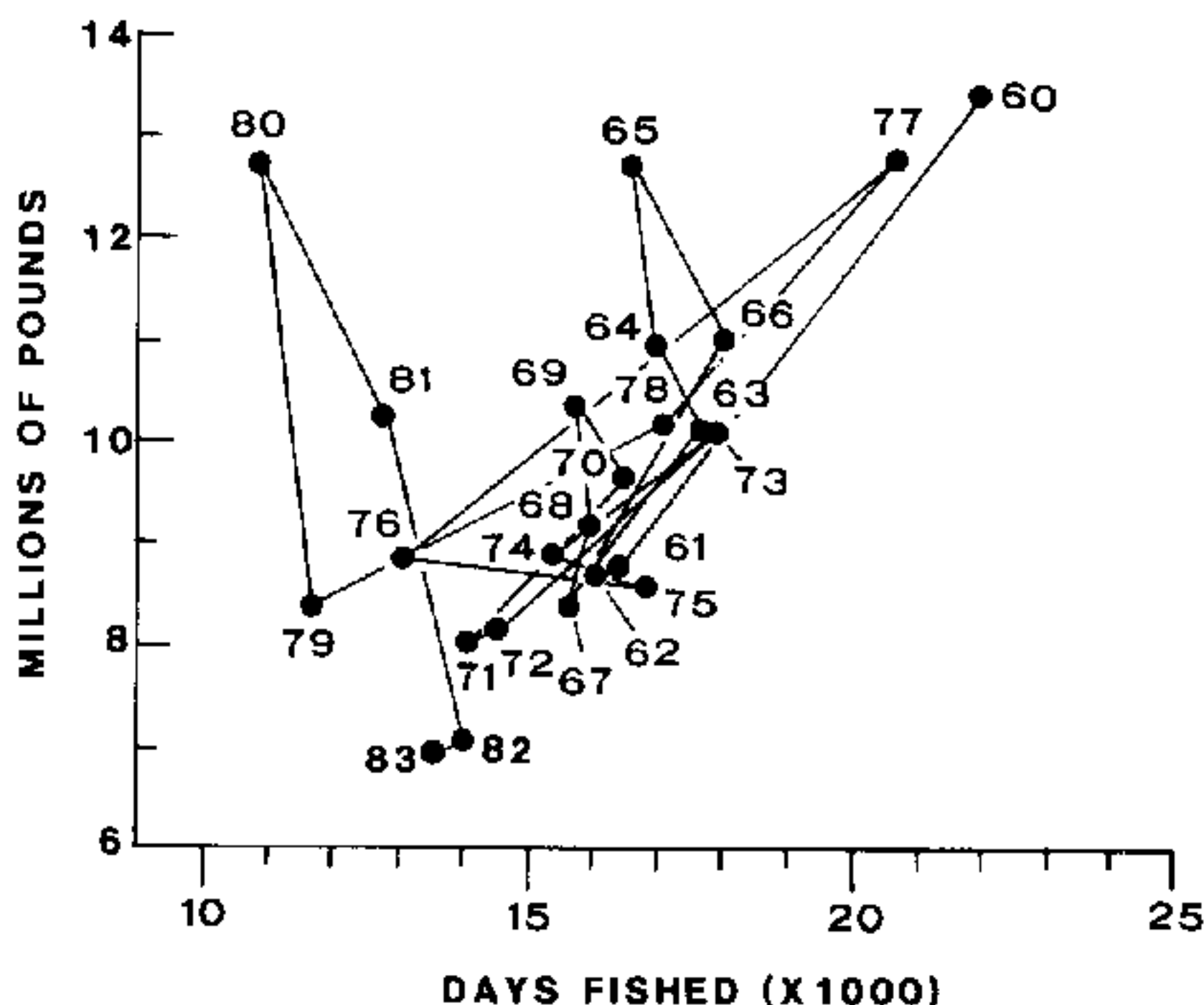


FIGURE 14.—Catch of pink shrimp versus fishing effort in biological years 1960–1983 for the Tortugas grounds (subareas 1–3).

1964 and 1975–1979. We feel, however, that this is a reflection of the lack of recruitment in 1982, to the good recruitment that occurred from March to April of 1981, and somewhat to the quantity of pink shrimp caught illegally within the closed area.

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